AUVS
ADVANCED ULTRA-VIOLET SYSTEMS

BioProtector 3131

Commercialized Version

of Department of Defense Design

Enhanced UV-C In-Chamber

Air Disinfection

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Proven to Kill, Rather Than Trap Pathogens

The **BioProtector 3131 (BP3131)** is a commercialized version of the inline HVAC ductwork disinfection system designed for the Department of Defense to kill biological threats.

Small pathogens such as bacteria and viruses may be too small to trap with HEPA/Ultra HEPA filtration, or pass-through poor sealing between the filtration and the frame.

Pressure drop with HEPA filtration may also exceed the HVAC system's ability to meet required air exchanges.

The AUVS BP3131 kills pathogens rather than trapping them eliminating pressure drop.

AUVS Technology

The AUVS technology created for the US Department of Defense Immune Building Program is based on an innovative and patented UV enhancement or “photon multiplication” technology that permits the use of relatively low power UV sources to achieve high microbial kill levels.

This technology permits the creation of very intense, highly uniform UV doses without increasing the input power.
The approach is analogous to that of a microwave or laser cavity.

Flowing air generally moves rapidly past the location where the UV power is applied, high power levels are needed to acquire sufficient dose to generate disinfection effects in a short time.

This is quite different from applying UV to a stationary coil over a long time to achieve disinfection of the coil.

BioProtector products accomplish disinfection of rapidly moving air using a highly reflective chamber to contain and multiply the flux from high power UV lamps. The size of the chamber is designed to provide adequate dose for a specified airflow volume (cfm). Specifically, a given airflow volume along with the size of the chamber defines an airflow velocity in ft/min and a dwell time in the chamber in seconds. This in turn, along with the UV power defines the dose accumulated by a volume of air and the resulting level of disinfection.

BioProtector 3131 Specifications	
Overall Dimensions	36” H x 68“D x 41” W
Input Voltage and Wattage	120 VAC 1693.8 Watts
Weight	130 lbs.
Power	120V /240 VAC, 50/60 Hz,2400 Watts
Light Source	Mercury Germicidal UV Lamps (12)
Wavelength	>85% Output at 253.7 nm
Average Lamp Life	10,000 hours
Airflow Volume	2000 CFM to 3000CFM

BioProtector 3131 Testing and Results

Staph Aureus and Sars-Cov-2 surrogate
2000 CFM enough for a typical 600 square foot Operating Room with 10 ft ceiling and 20 air exchanges per hour.
A 1 second exposure of the airborne tested pathogens shown in the BP3131.

Single Pass Test Results
Below is the result of the kill level with the air passing through the chamber just once.

Staphylococcus Aureus:
Sample time for 30 Minutes

5.1 Log 99.999% Disinfection

Unit Off		
	Upstream	Downstream
Concentration (CFU/ft^3)	2.33×10^6	1.14×10^6
Log(concentration)	6.37	6.05

Unit On		
	Upstream	Downstream
Concentration (CFU/ft^3)	2.49×10^6	19.81
Log(concentration)	6.40	1.30

MS-2 bacteriophage:
Sample time was 45 Minutes

3.7 Log 99.97% Disinfection

Unit Off		
	Upstream	Downstream
Concentration (PFU/ft^3)	4.73×10^6	3.12×10^6
Log(concentration)	6.67	6.49

Unit On		
	Upstream	Downstream
Concentration (PFU/ft^3)	2.31×10^6	6.5×10^2
Log(concentration)	6.36	2.81

System Description

The HVAC controller provides the ability to turn on/off and monitor a bank of up to 6 UV ballasts along with their associated UV lamps. The system consists of a cabinet holding up to 12 UV lamps installed inline with the HVAC duct work. When air flow is detected within the cabinet the lamps are illuminated. Each ballast provides an output signal which indicates that the UV lamps have illuminated correctly, or whether there is a fault present. Should a fault be detected indication is provided on both a remote indicator panel as well as an indicator at the HVAC controller.

Internal Operation

Fundamental operation of the HVAC Controller involves a microcontroller, a differential air pressure sensor, a high current relay and a method for detecting fault conditions.

In normal operation the microcontroller repeatedly measures the differential air pressure between the inside of the cabinet and atmospheric pressure. When the differential pressure exceeds a predefined threshold, it is determined that air is flowing within the system and the high current relay will be energized thus providing power to each of the ballasts.

After a 10 second delay each ballast and tube combination is expected to be fully active, and the microcontroller begins monitoring for fault conditions as reported by the ballasts. Should a fault be detected, this is indicated using an LED mounted on the HVAC controller. There is one LED per ballast/tube pair and this LED is latched in the on state regardless of whether the ballasts are subsequently turned off due to lack of air flow.

The microcontroller also monitors the UV level as measured inside the cabinet via an external sender. Should the tubes be illuminated, and the level be below a predefined threshold another LED is turned on indicating a 'UV Low' event has occurred.

When the differential pressure returns to a level indicating there is no longer airflow in the cabinet then power is removed from the ballasts by de-energizing the main relay.

To allow independent systems to also monitor the condition of the HVAC controller two interfaces are provided:

1. A status relay
2. A RS485 Modbus interface

The status relay provides the simplest indication of the health of the HVAC controller. When active the system is working correctly, but when de-energized then a service is required.

The Modbus interface provides much finer status reporting and is most suitable when an existing building control network is present. If necessary, a gateway device is used to interface between the existing network and the HVAC controller. The existing building control system can now read the individual condition of each ballast/tube pair along with any other diagnostics available.

BioProtector 3131 Performance

1. Measured Irradiation, Calculated Transit time and Calculated Dose

AIRFLOW (CFM)	1000	2000	3000	4000	5000	6000
MEASURED IRRADIATION (mW/cm2)	14.70	14.70	14.70	14.70	14.70	14.70
AVERAGE FLOW VELOCITY (FT / MIN)	149.8	299.7	449.5	599.4	749.2	899.1
FRACTION OPEN AREA OF ENDS	0.35	0.35	0.35	0.35	0.35	0.35
ESTIMATED PRESSURE DROP (IWG)	0.03	0.12	0.26	0.47	0.73	1.06
AVERAGE RESIDENCE TIME (SEC)	2.00	1.00	0.67	0.50	0.40	0.33
AVERAGE DOSE (mJ/cm2)	29.43	14.72	9.81	7.36	5.89	4.91

2. Disinfection Performance at 2000 cfm

Air Velocity: 300 ft/min

Exposure Time: 1.0 sec

Single Pass Dose: 14.7 mJ/cm^2

Measured Disinfection Test Results with BP3131 at 2000 cfm:

Staphylococcus aureus: 5.1 logs (99.999%)

MS-2 bacteriophage test virus: 3.55 logs (99.97%)

CALCULATED SINGLE PASS KILL IN FLOWING AIR- BP3131 - 2000 CFM (DOSE = 14.7 mJ/cm^2)

Microorganism	Type	Measured D-Value[1] (mJ/cm^2)	Reference	Calculated Kill (logs)	Calculated Kill (%)
Bacillus anthrasis	Bacteria	4.51	Sharp (1938)	3.3	99.94
Bacillus subtilis	Bacteria	7.1	Rentschler,et al (1941)	2.1	99.15
Escherichia coli	Bacteria	0.612	Sharp 1940	24.0	>>99.9999
Salmonella typhi	Bacteria	2.1	Sharp 1938	7.0	>99.9999
Pseudomonas aeruginosa	Bacteria	0.4	Sharp 1940	36.8	>>99.9999
Serratia marcescens	Bacteria	2.4	Rentschler et al 1941	6.1	>99.9999
Shigella paradysenteriae	Bacteria	1.7	Sharp 1938	8.6	>99.9999
Staphylococcus albus	Bacteria	1.8	Sharp 1938	8.2	>99.9999
Staphylococcus aureus	Bacteria	0.662	Sharp 1939	22.2	>>99.9999
Staphylococcus hemolyticus	Bacteria	2.15	Sharp 1938	6.8	>99.9999
Streptococcus lactis	Bacteria	6.22	Rentschler et al 1941	2.4	>99.9999
Mycobacterium tuberculosis	Bacteria	0.487	Riley 1976	30.2	>>99.9999
Adenovirus	Virus	4.2	Jensen 1964	3.5	99.97
Vaccinia	Virus	1.5	Jensen 1964	9.8	>99.9999
Coxsackievirus	Virus	2.1	Jensen 1964	7.0	>99.9999
Influenza A	Virus	1.9	Jensen 1964	7.7	>99.9999
SARS-CoV-2[2]	Virus	4.17	Inagaki 2020	3.5	99.97
SARS-CoV-2[3]	Virus	1.23	Bianco 2020	12.0	>>99.9999

Notes:

1. D-Value = Measured Dose required for 1-log reduction (in Air unless noted)
2. Tests in vitro
3. Tests on surface

HEPA Filtration (Trap Bacteria and Virus) versus AUVS BioProtecor 3131 (Kill Bacteria and Virus)

HEPA Filtration	AUVS BioProtector 3131 (BP3131)
HEPA filters are designed to filter 99.97 percent of particles with a diameter of 0.3 microns. The size of 0.3 microns is the most evasive for a particulate filter.	Staphylococci are Gram-positive cocci about 0.5 – 1.0 µm in diameter. (SSI from airborne MRSA) SARS-CoV-2 is an enveloped virus ≈0.1 µm in diameter. (Virus that causes Covid)
Poorly maintained filters with inadequate seals and breaches in the filter media promote the passage of contaminants into occupied spaces. This seriously affects IAQ in critical areas.	BP3131 is a permanent unit and sealed as part of the HVAC ductwork.
Severely occluded particulate filters increase the resistance of airflow through the filters, affecting air supply rates. When filters are not changed according to the manufacturer's instructions, the performance of the HVAC system is compromised.	BP3131 kills the pathogens with no pressure drop.
Due to variations in state building codes, 15 or 20 air changes per hour (ACH) may be the minimum required. However, in practice, most hospitals operate at 20 to 25 ACH with some using up to 40 ACH.	No pressure drop or impact on air exchanges (ACH) with the BP3131.
HEPA filters, while very effective, are thick and dense. These qualities can substantially interfere with the airflow process of your HVAC equipment. If the airflow is restricted, the heating and cooling demand on the property will increase, forcing utility bills to skyrocket and potentially causing damage to the whole HVAC system.	No interference with the airflow of the HVAC with the BP3131.
Power, because of the higher pressure drop through HEPA filters, they require about 15 percent more horsepower to operate, so more energy is used. Also keep in mind that the air handling unit itself may need to be bigger to house HEPA filters because of their larger size.	No pressure drop or interference with the airflow or air exchanges or increase in HVAC system HP.
Cost of purchase and maintenance, HEPA filters are not only more expensive upfront, they also require increasing, ongoing maintenance costs. These filters need to be replaced once or twice a year depending on the environment of the plant and pressure drop.	Lamps need to be replaced every two years, energy costs $80/month on average.
Viruses are also too small to be removed. Despite this fact, HEPA based products were marketed for a long time with the claim to protect from viruses. The US Federal Trade Commission (FTC) has now regulated that HEPA filter-based products can no longer make that claim.	The BioProtector has been tested by an independent consulting lab for Staphylococcus Aureus to 5.1 log kill (99.999%+) and MS-2 bacteriophage (EPA approved surrogate for Sars-Corona virus) to 3.7 log kill (99.97%). This was single pass through the BP3131 at 2000 CFM which is 20 air exchanges for a typical 600 square foot OR with a 10-foot ceiling.
Bacteria: While bacteria are large enough to be trapped, bacteria are understood to release endotoxins (toxin that is present inside a bacterial cell and is released when the cell disintegrates), into the air stream when dying on the air filter surface.	The dead bacteria exits the BP3131, toxins are not trapped on the HEPA filter media since it is not required.
HEPA filters with trapped live viruses and bacteria must be very carefully handled to avoid shaking them loose into the HVAC or exposing employees, creating a hazardous work environment.	Not applicable with BP3131

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